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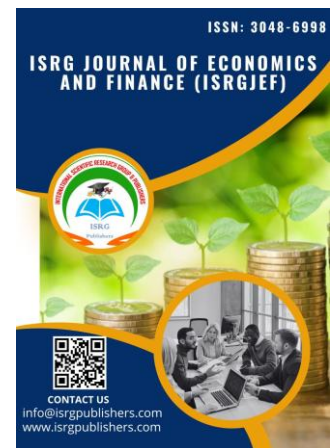
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## Enhancing Community Involvement in the Development and Implementation of Affordable and Sustainable Energy Solutions in Maiduguri

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### Abstract

*This study examined the role of community participation in enhancing the development and implementation of affordable and clean energy solutions in Maiduguri, Nigeria. The study was motivated by persistent energy poverty, unreliable electricity supply, and the growing need for sustainable energy alternatives within conflict-affected and rapidly expanding urban communities. A descriptive survey research design was adopted, and primary data were collected from 186 respondents comprising community members, energy users, local leaders, and stakeholders involved in renewable energy initiatives. Data were analyzed using descriptive statistics and regression analysis to determine the relationship between community participation and clean energy development outcomes. Findings revealed that community participation significantly improves accessibility, affordability, and sustainability of renewable energy solutions, particularly decentralized solar energy systems. The study further established that active involvement of community members enhances local ownership, encourages maintenance culture, and promotes acceptance of clean energy technologies. However, major challenges identified include high installation costs, limited technical capacity, low awareness levels, and institutional constraints affecting implementation. The study concludes that strengthening participatory governance and community engagement is critical for achieving sustainable energy development and improving socioeconomic resilience in Maiduguri. The study recommends increased stakeholder collaboration, financial support mechanisms, community capacity building, and inclusive policy frameworks to accelerate the adoption of affordable and clean energy solutions in underserved communities.*

**Keywords:** Community Participation, Affordable Energy, Clean Energy Solutions, Renewable Energy, Sustainable Development, Maiduguri.

## 1.0 Introduction

Access to affordable and clean energy forms one of the major development challenges encountered by many developing countries particularly sub-Saharan Africa (Al-Amin et al., 2025; Sadiq et al., 2025). In spite of the high level of natural resources available and the increased demand for electricity in Nigeria, the country still suffers from massive electricity deficits (Inyang et al., 2025). Many people in Nigeria lack access to a reliable source of electricity, which impacts socioeconomic development, economic productivity and wellbeing (Dinneya-Onuoha, 2025). The energy poverty of the North-Eastern region including Maiduguri, is worsened by the infrastructure damage, population displacement and the rapid urbanization which takes place in the region, thus making the need for sustainable energy solutions and inclusive is a necessity for the region.

Affordable and clean energy is directly related to the United Nations Sustainable Development Goal 7 (SDG 7): Ensure access to affordable, reliable, sustainable and modern energy services. Renewable energy technologies, such as solar mini-grids, biomass systems, and decentralized off-grid solutions, have shown promise as viable alternatives for underserved communities (Tanko et al., 2025; Ibrahim et al., 2025). Research studies have shown that decentralised renewable energy (DRE) systems have the ability to power communities that are remote or marginalized and which are inaccessible by the national grid (Babalola et al., 2022). The importance of the systems in the context of Maiduguri is that decentralised power systems are not fit for the city's increasing energy needs.

The value of Community participation in Sustainable Energy projects is growing in recognition. Community-based renewable energy projects promote community ownership, enhance social acceptability, and help ensure the sustainability of energy systems in the long run. In the Nigerian experiences, local stakeholders' participation in project planning and decision-making is crucial in ensuring effective project execution, fostering inclusive development outcomes, and establishing a maintenance culture (Akpan, 2023, Christian & Effiong, 2023). If the energy intervention isn't meaningful to people, if it is distrusted, or if it doesn't fit with community priorities, then it is unlikely to be successful.

Further, there is a need for arrangements of the governance and multi-level cooperation to support clean energy transitions. Including community perspectives in national and local energy policies fosters adaptive energy governance, which can address local energy conditions. Studies have revealed that the citizen involvement and community renewable energy models are key to improving the effectiveness of policies and support sustainable energy consumption in Nigeria (Energy Research & Social Science, 2025). The participatory governance models are of great significance in conflict-prone areas like Maiduguri and fostering inclusive development policies implementation for creating resilience (Zailani et al., 2025).

However, several challenges are still affecting Nigeria to promote the use of Renewable Energy Resources (RESRs) in the country despite its huge potential. There are still challenges in the renewable energy industry, such as policy inconsistencies, financial constraints, technical capabilities, and community involvement (Ajia, 2025). These barriers need to be overcome with a paradigm change from the traditional approach of top-down energy planning to participatory development models which

involve communities as active partners rather than mere beneficiaries. Community-based solutions also promote social innovation, employment opportunities, and energy equity.

Therefore, enhancing the involvement of the community in the development and application of affordable and clean energy is one of the strategic measures to consider for sustainable development in Maiduguri. Local knowledge, stakeholder participation and decentralised renewable energy systems can be integrated into energy interventions to make them more resilient, inclusive and sustainable. This study seeks to understand how participatory methods can enhance outcomes of energy access and foster environmental sustainability and long-term socio-economic recovery and development in vulnerable urban settings such as Maiduguri.

## 2.0 Literature Review and Theoretical Framework

### 2.1 Conceptual Review

#### 2.1.1 Community Participation

Community participation is the active engagement of community members in the process of need identification, planning, decision making, implementation and evaluation of development activities which are to impact their lives (Hafizu et al., 2025). It is based on empowerment, inclusiveness and responsibility sharing among stakeholders and beneficiaries (Bello et al. 2025). Arnstein (1969) has identified a continuum of community participation, from passive recipients of information to true citizens in control of development processes. In the contemporary development theory, participation is seen as a means to enhance the sustainability of projects, the accountability of projects, social acceptance of projects, particularly in the field of infrastructure and energy projects. Community participation has been shown to provide opportunities for communities to share their own expertise, enhance ownership and engage interventions to meet local socio-economic realities (Cornwall, 2008). Engaging in project development in the community pushes maintenance culture, embeds behavioural acceptance of technologies and leads to better project outcomes.

#### 2.1.2 Development

Development is multidimensional, which includes economic growth, social transformation, institutional improvement and human well-being enhancement (Ologbonori et al., 2025). Other concerns like education, health and sustainability, equity and freedom of man are now emphasized in the modern perspective. According to Sen (1999) development is an expansion of the capacities and opportunities of people to live the lives they value. Similarly, Todaro and Smith (2020) point out that development is not only defined as the reduction of poverty, inequality and unemployment but also as improving the quality of life and ensuring access to basic services, such access to energy, health and education. Development at the local level is characterised by rebuilding infrastructure, boosting resilience, inclusive governance, livelihoods development, sustainable use of resources, community-based approaches and, in Maiduguri, the improvement of the resilience of local communities.

The use of affordable, clean energy solutions is encouraged.

Energy solutions that are affordable and clean: Energy systems that are economically accessible, environmentally sustainable, reliable and capable of satisfying the current energy demands without jeopardizing future generations. These solutions are essential to

meet the Sustainable Development Goal 7 of the United Nations (2015) "Ensure access to affordable, reliable, sustainable and modern energy services for all. There are various known solutions to improve energy access in the developing world, such as renewable energy technologies like solar PV, wind, biomass and mini-grid electrification. In the report 'Decentralised Renewables: Technology Roadmap 2023', the International Energy Agency (IEA) states that decentralised renewable energy systems can cut down on greenhouse gas emissions, enhance energy security and facilitate local economic development. In regions where energy poverty is a major challenge, access to affordable clean energy plays a crucial role in achieving sustainable community development, which can provide improved health facilities, education, and the promotion of small business, as well as environmental protection.

## **2.2 Theoretical Framework**

### **2.2.1 Participatory Development Theory**

The study on advancing community participation in affordable and clean energy solutions is tightly coupled with Participatory Development Theory, which focuses on the role of local communities in the planning, decision-making and implementation processes. This theory came to represent the response to the traditional development models that were generally downwards and overlooked the local requirements and realities. Chambers (1997) proposes that sustainable development is more likely to be realised if beneficiaries can be seen as active rather than passive agents of development interventions. All the concepts of Participatory Development Theory presented in this paper are very fundamental in the success of any renewable energy project in an underserved community such as Maiduguri with the ultimate aspiration of empowering, owning, building capacity and sharing responsibility for the project. The participatory approaches include integrating community knowledge, values and governance structures to enhance the acceptance, sustainability and accountability of projects (Hickey & Mohan, 2004). This theory provides a good foundation for studying IES as a means to improve the development and deployment of affordable, clean energy solutions.

### **2.3 Empirical Reviews**

Akinyele, Rayudu and Nair (2020) did a study entitled Community Based Renewable Energy Planning for Sustainable Rural Electrification in Nigeria. The study adopted quantitative modelling approach and the Low Emissions Analysis Platform (LEAP) model in the study of community scale renewable energy planning in rural communities of Nigeria. It was discovered that incorporating community involvement in the planning of renewable energy projects led to a substantial decrease in energy demand costs and GHGs, and enhanced access to electricity. The study recommended to increase the local involvement of stakeholders and more decentralization of energy governance to improve sustainability outcomes.

Monyei, Adewumi, Jenkins and Viriri (2021) have discussed about Challenges and Opportunities of Energy Access in Sub-Saharan Africa: Community Renewable Energy Systems. Overall, it concluded that community participation can be a driver of increased ownership, system maintenance and sustainability of off-grid renewable energy systems. The authors recommended the inclusion of community education programmes and participatory governance models in the renewable energy deployment strategies.

Olanrewaju et al., (2022) carried out a research work on some determinants of renewable energy adoption in Nigerian communities. Survey methodology and regression analysis were used in the research across selected communities in Nigeria. The results revealed that awareness and cooperation of communities were important factors in promoting the use of renewable energy (RE), along with participative decision making. The study recommended to produce community mobilization programmes and make microfinance more accessible for clean energy technologies.

In 2023, Decentralised Renewable Energy and Community Development in Africa was explored by the United Nations Development Programme (UNDP). This study employed a case study approach which was applied to different African countries with community mini-grid projects. They found that communities that were engaged in the planning and implementation process had positive results and a higher success rate, as well as better socio-economic outcomes. The report recommended improving local institutions and enhancing energy governance for gender inclusion.

Okolie and Eze (2024) empirically studied the topic: Community Participation and Sustainability of Solar Mini-Grids in Northern Nigeria. Structured questionnaires and structural equation modelling were used to establish the results of the study which revealed that community ownership, local community leaders' involvement in the process, and training significantly affected the culture of maintenance and the affordability of solar energy systems. The scientists suggested forming community energy committees to make sure of renewable energy projects in the places where they are needed.

The International Renewable Energy Agency (IRENA) (2025) shared results in Renewable Energy for Community Resilience and Inclusive Development. The method used in the study was comparative empirical analysis, which was carried out by comparing the developing countries which have integrated renewable energy projects in their communities. The findings showed the impact of the community on minimizing the risk of project failure, affordability of projects, and inclusive economic development. The report proposed mainstreaming the approach of CLRE financing types and integrating local knowledge in national energy planning mechanisms.

### **2.4 Research Gap**

There has been a growing body of empirical research on access to renewable energy and participation of communities but there are some important gaps which are justified in the present study. Past studies by Akinyele et al (2020), Monyei et al (2021) and Olanrewaju et al (2022) have been primarily geared towards national or regional level of Renewable energy adoption, policy and technological deployment without paying adequate attention to conflict affected urban centres like Maiduguri. In more context, UNDP (2023) and IRENA (2025) identified community engagement as one of the major factors that contribute towards success, but lacked the level of understanding required on the interplay between community, climate and socio-cultural factors that influence participation in the northeast of Nigeria. While Okolie and Eze (2024) explored how communities are engaged in the sustainability of solar mini-grids, their study was focused primarily on the technical sustainability outcomes with less of an emphasis on participatory mechanisms throughout the entire development and implementation process of affordable and clean energy solutions. Lacking, therefore, are, specifically, the empirical

evidence of the impact of community participation on planning, implementation, cost and sustainability of clean energy projects in the unique socio-economic and post conflict setting of Maiduguri. This study, therefore, fills the vacuum because it is a localised, participatory study involving community participation and the affordable and clean energy development outcomes in Maiduguri.

### 3.0 Methodology

#### 3.1 Research Design

This study utilized descriptive survey research design. It was found that the design was suitable because it would enable the researcher to obtain response from a specific population in a specific area and also it would enable the researcher analyse the level of community participation in the implementation and development of affordable and clean energy solutions in Maiduguri. The survey method allows for quantitative data to be collected on perceptions, experiences and participation rates of community members, energy stakeholders and renewable energy programme beneficiaries. It also enables the investigation of correlations between community engagement and sustainable energy results.

#### 3.2 Area of the Study

The study was conducted in Borno State whose capital is Maiduguri, Nigeria. The emergence of the city of Maiduguri as a strategic location makes it an ideal place for the study because of the population growth, energy supply problem and recovery from socio-economic disruptions from insecurity and infrastructural destruction. The decentralized renewable energy solutions (like solar home systems and mini-grids) have been implemented in the city, which provides a suitable context for studying the role and involvement of the community in the implementation of echelon energy solutions.

#### 3.3 Population of the Study

The population studied were the community, the energy service providers, government leaders, energy users and the non-governmental organizations (NGOs) involved in clean energy projects in Maiduguri. Groups have been chosen with an understanding that they have an important role to play as a beneficiary, implementation or regulatory body within the development of community energy projects.

Sample size > 30 is large. If the sample size is greater than 30, it is considered large.

The number of respondents selected from the target population size was about 200. A multi-stage sampling technique was used for the study. The selected communities in Maiduguri were purposively selected as a result of the presence of renewable energy interventions in the communities. Secondly, stratified sampling was done to facilitate grouping of the constituencies to appropriate stakeholder groups. Lastly, simple random sampling was used to select individual participants ensuring fairness and representation.

#### 3.4 Sources of Data

This study used primary data source. The structured questionnaires used to gather the primary data to obtain information on community participation, access to clean energy, affordability, implementation processes and perceived sustainability outcomes were administered to the respondent.

The 3.6 Instrument for Data Collection is an instrument suitable for collecting data.

The main data collection tool was the structured questionnaire using 5 point Likert scale from Strongly Agree (5) to Strongly Disagree (1). The questionnaire included questions on demographic information, community engagement, availability of clean energy options, economies, barriers to implementation, and the sustainability effects.

The questions are considered as valid for the instrument.

The questionnaire was expert checked by professionals in the fields of energy studies, development studies and research methodology to ensure the validity of the questionnaire. Their feedback and suggestions were used to enhance the clarity, relevance and content coverage of the instrument.

The instrument is accurate. The instrument is reliable, 3.8

To determine the reliability of the instrument, Cronbach Alpha reliability test was determined by conducting a pilot study to the respondents outside the main study area. The internal consistency for items of the measurement has acceptable reliability coefficient of 0.7 and above.

The data collection technique used was:

Questionnaires were directly administered with a trained research assistant and data were gathered. The method employed led to better return and allowed for clarifying of questions when desired.

The data for the analyses was obtained from the following sources:

Descriptive and inferential statistical methods were used to analyze the data collected using the aid of Statistical Package for Social Sciences (SPSS). Frequencies, percentages, means and standard deviations were used to summarize responses. Inferential statistics like regression analysis and correlation analysis were used to understand the correlation between community participation and the effectiveness of affordable and clean energy solutions.

#### 3.5 Ethical Considerations

Ethical guidelines with regard to the conduct of the study were carefully adhered to. The participation was voluntary, respondents' confidentiality and anonymity was ensured and informed consent was obtained before data collection. Confidentiality of the provided information was ensured to the respondents that it would be used only for academic purposes.

Identify and present findings and discuss in terms of data analysis process.

### 4.0 Data Presentation and Analysis of results

In this section, the findings of the respondents are presented, the data gathered from them, about the engagement of the community in the development and implementation of affordable and clean energy solutions in Maiduguri was analysed. Webster et al. (2005) reported that 200 questionnaires were sent out and that 186 were returned and analysed (a 93% return rate). The analysis includes demographic characteristics of respondents, level of community participation, access to affordable clean energy, challenges faced, the effectiveness of implementation and regression analysis looking at relationships between variables.

**Table 4.1: Gender Distribution of Respondents**

Gender	Frequency	Percentage (%)
Male	112	60.2

Gender	Frequency	Percentage (%)
Female	74	39.8
<b>Total</b>	<b>186</b>	<b>100</b>

Source: Field Survey, 2026

The table 4.1 shows that 60.2% of respondents were male while 39.8% were female. This indicates that both genders were adequately represented in the study, although males constituted the majority of participants involved in community energy activities. The gender distribution reflects existing participation patterns within community development and energy initiatives where men often dominate public engagement structures.

**Table 4.2: Age Distribution of Respondents**

Age Group	Frequency	Percentage (%)
18–30 years	48	25.8
31–40 years	67	36.0
41–50 years	45	24.2
Above 50 years	26	14.0
<b>Total</b>	<b>186</b>	<b>100</b>

Source: Field Survey, 2026

Table 4.2 indicates that most respondents (36.0%) fall within the 31–40 age bracket, suggesting active participation of economically productive individuals in clean energy initiatives. Younger and middle-aged populations appear more engaged in community participation processes, likely due to greater exposure to energy innovation and community development programs.

**Table 4.3: Educational Qualification of Respondents**

Qualification	Frequency	Percentage (%)
Primary Education	32	17.2
Secondary Education	71	38.2
Tertiary Education	65	34.9
No Formal Education	18	9.7
<b>Total</b>	<b>186</b>	<b>100</b>

Source: Field Survey, 2026

Table 4.3 Results reveal that most respondents possessed at least secondary education (38.2%), while 34.9% had tertiary education. This suggests that respondents generally had sufficient literacy levels to understand and participate in community energy programs, which enhances awareness and adoption of affordable clean energy solutions.

#### 4.4 Community Participation in Clean Energy Development

**Table 4.4: Level of Community Participation**

Response	Frequency	Percentage (%)
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Response	Frequency	Percentage (%)
Strongly Agree	72	38.7
Agree	66	35.5
Neutral	21	11.3
Disagree	17	9.1
Strongly Disagree	10	5.4
<b>Total</b>	<b>186</b>	<b>100</b>

Source: Field Survey, 2026

The findings in table 4.4 indicate that a large proportion of respondents (74.2%) agreed that communities actively participate in energy development initiatives. This demonstrates growing involvement of residents in decision-making and project implementation processes, supporting the idea that participatory approaches are increasingly recognized in Maiduguri's clean energy programs.

#### 4.5 Accessibility of Affordable and Clean Energy

**Table 4.5: Accessibility of Clean Energy Solutions**

Response	Frequency	Percentage (%)
Strongly Agree	60	32.3
Agree	70	37.6
Neutral	24	12.9
Disagree	20	10.8
Strongly Disagree	12	6.4
<b>Total</b>	<b>186</b>	<b>100</b>

Source: Field Survey, 2026

Table 4.5 shows that 69.9% of respondents agreed that affordable and clean energy solutions are increasingly accessible in Maiduguri. This suggests progress in renewable energy deployment, especially solar energy systems and decentralized solutions that compensate for unstable grid electricity supply.

#### 4.5 Affordability of Clean Energy Solutions

**Table 4.6: Affordability of Renewable Energy Systems**

Response	Frequency	Percentage (%)
Strongly Agree	55	29.6
Agree	68	36.6
Neutral	29	15.6
Disagree	21	11.3
Strongly Disagree	13	7.0
<b>Total</b>	<b>186</b>	<b>100</b>

Source: Field Survey, 2026

Table 4.6 results reveal that 66.2% of respondents perceived renewable energy solutions as affordable. This indicates that community-based financing mechanisms, shared energy systems, and falling solar technology costs may be improving affordability, although some respondents still experience financial barriers.

#### 4.6 Challenges Affecting Implementation

**Table 4.7: Challenges Facing Clean Energy Implementation**

Challenge	Mean Score
High initial installation cost	4.21
Limited technical skills	3.88
Low community awareness	3.76
Policy and institutional barriers	3.69
Maintenance difficulties	3.54

Source: Field Survey, 2026

Table 4.7 shows that the highest installation cost recorded the highest mean score (4.21), identifying it as the most significant challenge to clean energy implementation. Other issues, such as technical capacity gaps, limited awareness, and policy constraints, also affect the sustainability of energy projects within the community.

#### 4.7 Regression Analysis

**Table 4.8: Effect of Community Participation on Clean Energy Development**

Variable	Coefficient	t-Statistic	Sig.
Constant	0.912	4.102	0.000
Community Participation	0.463	5.874	0.000
Accessibility	0.298	3.611	0.001
Affordability	0.241	2.995	0.003

Source: Field Survey, 2026

The regression results in table 4.8 indicate that community participation has a positive and statistically significant effect on affordable and clean energy development ( $\beta = 0.463$ ,  $p < 0.05$ ). Accessibility and affordability also significantly influence successful implementation. The findings confirm that increased community involvement improves adoption, sustainability, and effectiveness of energy initiatives in Maiduguri.

#### 4.8 Discussion of Findings

The study found that the involvement of the community is an important factor in the realization of affordable clean energy solutions in Maiduguri. Many participants reported that their projects used participatory development methodologies, which increased project acceptance and sustainability. This fits into participatory development theory which places importance on ownership as a prerequisite for successful development interventions.

Moreover, it was found that the clean energy technologies were more accessible and affordable. The decentralized renewable generation systems seem to be filling the gap in the supply of

electricity due to the increasing unreliability of the electricity grid. Making things easier helps to enhance welfare in the household, productivity of small businesses, and community resilience.

The study also found that some implementation challenges remain, though, such as high installation costs, technical capacity constraints, and policy constraints. These barriers suggest that participation of the community in these activities contributes to positive results; but institutional support, financing and capacity building are still required to infuse long-term sustainability. Therefore, effective government agency and community collaboration with private investors is crucial to scaling affordable and clean energy solutions in Maiduguri.

## 5.0 Conclusion and Recommendation

The study explored the involvement of the community in promoting the development and utilization of affordable and clean energy solutions in Maiduguri. The results showed that community engagement is a key driver of increased access, cost-effectiveness, and sustainability for renewable energy projects. Participation of the community was seen to foster local ownership, increase the acceptance of clean energy technologies, and establish a culture for maintenance, which were all integral to the success of the project. The study also found that access to clean energy is slowly improving with the use of decentralized renewable energy systems like solar solutions, but factors such as high installation costs, lack of technical skills, and institutional barriers are still limiting the broader uptake of clean energy. The study finally concluded that in general participatory methods are still very important in achieving sustainable energy development and socioeconomic recovery in Maiduguri.

The study suggests, based on these findings, that there is a need to institutionalize community participation in the planning, implementation and monitoring of energy projects by the government, development partners and the private sector. Policies should facilitate community energy committees and local capacity building programs, as well as provide financial incentives, including subsidies and microcredit schemes and public-private partnerships, to make these services more affordable. Moreover, it is crucial to step up awareness campaigns and technical training efforts to foster community understanding and sustainability of renewable energy systems. Incorporating community perspectives in energy decision-making through collaborative governance mechanisms will be another driver of affordable and clean energy solutions in communities like Maiduguri that are not yet served.

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